

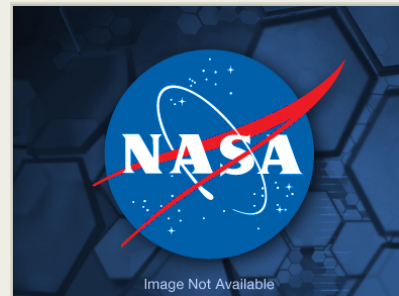
Membrane Extraction for Space Applications

Completed Technology Project (2016 - 2020)



Project Introduction

Goals & Objectives: Detection of extant life and assessment of habitability on ocean worlds is a high scientific priority for NASA. However, many of the analytical techniques commonly used to indicate signs of life rely on detection of complex, refractory biomolecules that may be low in abundance or difficult to sample. Gases, including light hydrocarbons and volatile organic compounds (VOCs) are a more plentiful and equally relevant set of analyte species that can be occluded in water and ice as both products of metabolism and indicators of habitability. These compounds (e.g., CO₂, CH₄) have been linked directly with biological activity on Earth in permanently ice-covered lakes in the Arctic and Antarctic. Our objective is to investigate a low-power variation of an extraction interface used routinely on Earth for laboratory and in situ analyses of gaseous, semivolatile, and water-soluble biosignatures from liquid samples. Specifically, we propose to further the technical readiness level (TRL) and reduce risk for a "static" (i.e., non-flowing sample) membrane introduction mass spectrometry (MIMS) interface for ultimate use in space applications, including lander missions with limited power budgets on ocean worlds. Membrane extraction is used in the well-established MIMS systems routinely deployed in Earth's oceans to detect light hydrocarbon, gases, and VOCs for scientific studies, and for resource and risk management. However, functionality of a "static" system has not been demonstrated at the breadboard level. **Approach & Methodology:** Traditional MIMS interfaces use a flow-through or flow-over scheme in which water samples are pumped over a gas-permeable hydrophobic membrane. A small fraction of volatile and relatively nonpolar analytes dissolve into the membrane as the water passes it, diffuse through it, and evaporate into the vacuum of the mass spectrometer (a process known as pervaporation), whereupon they are ionized and sorted by mass for identification and quantification. We propose a lower power MIMS interface that obviates the need for a power-hungry sample pump and reduces the volume of water needed for analyses. This "static" interface will receive liquid samples from which a large fraction of the volatile species will be extracted and delivered to a mass spectrometer (or possibly some other analytical instrument). The extraction method could ultimately be coupled with a gas processing system, including enrichment cells or gas chromatography, to concentrate volatiles of interest for analysis by mass spectrometry and other detectors. We will evaluate the efficacy of the "static" extraction approach and optimize the design and operation for quantification of relevant analytes. Our approach will evaluate (1) a variety of interface designs and membrane materials, including the commonly used polydimethylsiloxane (PDMS) and (2) sample concentration alternatives on the vacuum side of the membrane interface. For these studies the prototype MIMS interfaces will be coupled to a laboratory linear quadrupole mass filter system. **Program Element Scope & Suitability:** The membrane extraction system will be applicable for analysis of both solid ices (after melting) and liquids that may be found on a variety of ocean worlds. We respond directly to the NASA PICASSO solicitation (Program Element C.12) to develop and reduce the technical risks of



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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Planetary Instrument Concepts for the Advancement of Solar System Observations

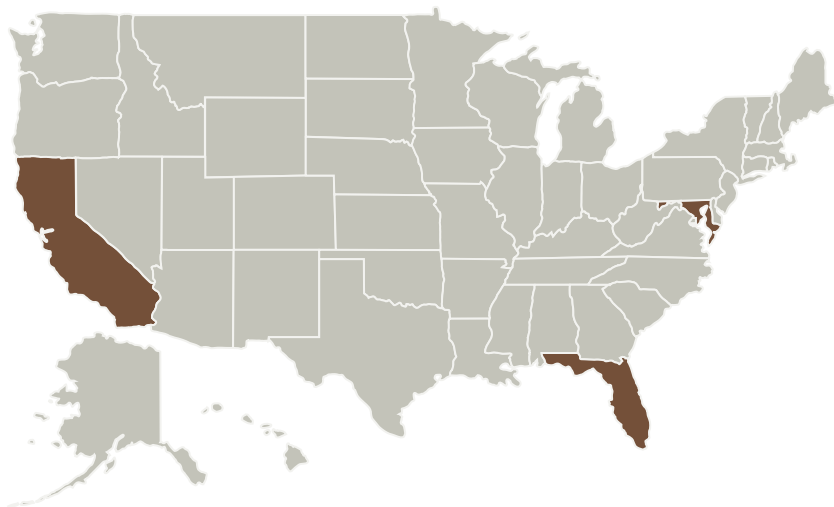
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component technologies so that they may later be proposed in response to Program Element C.13: Maturation of Instruments for Solar System Exploration (MatISSE). The analyte extraction and concentration capabilities of the proposed "static" membrane extraction system and its ability to provide analytes to a wide range of payload instruments are strategically aligned with the anticipated goals of an Ocean Worlds mission, specifically to search for biomarkers and evidence of extant life and to provide an in situ assessment of habitability.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
SRI International	Supporting Organization	Industry	Menlo Park, California

Primary U.S. Work Locations	
California	Florida
Maryland	

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

Haris Riris

Principal Investigator:

Robert T Short

Co-Investigators:

Zach Tyler

Friso H W Van Amerom

Veronica T Pinnick

Andres M Cardenas-valencia

Charles A Malespin

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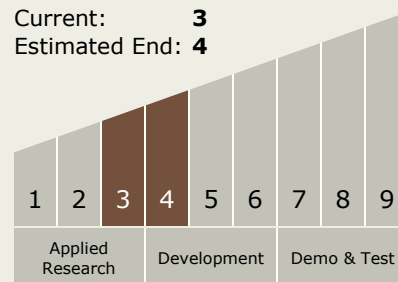
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Technology Maturity (TRL)

Start: 3

Current: 3

Estimated End: 4



Technology Areas

Primary:

- TX08 Sensors and Instruments
 - TX08.3 In-Situ Instruments and Sensors

Continued on following page.

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Technology Areas (cont.)

└ TX08.3.4 Environment
Sensors

Target Destination

Others Inside the Solar System